EFFECTS OF APACHE HELICOPTER CREW AND UNIT TRAINING ON COMBAT MISSION EFFECTIVENESS

Clarice T. Veit

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The RAND Corporation, 1700 Main Street, P.O. Box 2138, Santa Monica, CA 90406-2138

This paper reports preliminary findings from an investigation of the relationship between training programs for AH-64 (Apache) helicopter pilots and combat mission effectiveness. Data collection and analyses are still in progress.

THE RESEARCH PROBLEM AND METHODS

Two key questions are being addressed in this research.

- How can Apache aircrew and unit training be designed to improve overall combat mission effectiveness?

- Is it possible to train to the levels of proficiency needed in combat?

One reason for seeking answers to these questions is to better understand operational capabilities and limitations under different training programs. This was the primary research interest. Another important use for answers to these questions would be a basis for making cost/benefit tradeoff analyses (not a focus of the present research).

The research goal was to *causally* link important features of training programs to overall mission effectiveness. This is a formidable task: It requires assessing technological capabilities and training factors at both the individual crew and unit levels. Alternative research methods were considered, among them field studies and computerized simulation models. Large-scale field studies were ruled out because of their impracticality; they would require major restructuring of the system at great cost.[1] Further, field studies do not afford the opportunity to assess the effects of training with new

[1]For example, a major training feature is the number of hours per month a pilot flies his aircraft (the AH-64 in this case). In order to manipulate this training feature, different hours would have to be selected for different pilots (or units). Exploring the effects of this factor alone would require a complete restructuring of support systems (e.g., maintenance) that are geared for today's training hours; among other drawbacks, restructuring is quite costly. And, Number of Flying Hours is only one of several factors that need assessment.

technology (e.g., a new scout helicopter to accompany the Apache in its missions, such as the OH-58D). However, small-scale field studies as well as studies using the Apache combat mission simulator (CMS) are still being considered as a means of providing additional information on the effects of a restricted set of training factors. Computerized battle simulation models were ruled out, because these models typically require information on training effects as inputs.

Two research methods are being used in concert to accomplish the goal of causally linking training to combat mission effectiveness:

-the Subjective Transfer Function (STF) method[2], and

-The Algebraic modeling approach to subjective measurement.[3]

This combination of research methods can be used for developing causal models of activities or processes of complex systems. The steps involved in the STF method are to

- identify critical factors and mission outcomes in conjunction with subject matter experts (SMEs); and

- structure causal hypotheses (also with SMEs).

The major steps in the algebraic modeling method in general (with specifics focused on this research) are to

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[2] Veit, C. T., and Callero, M. Subjective Transfer Function Approach to Complex System Analysis. The RAND Corporation, R-2719-AF, March, 1981.

[3] Example references are: Anderson, N. H. "Information Integration Theory: A Brief Survey," in D. H. Krantz, R. C. Atkinson, R. D. Luce, and P. Suppes(eds.), Contemporary Developments in Mathematical Psychology, Vol. 2, Academic Press, New York, 1974; Birnbaum, M. H. "The nonadditivity of personality impressions," Journal of Experimental Psychology Monograph, 1974, 102, 543-561; Krantz, D. H., and A. Tversky, "Conjoint-Measurement Analysis of Composition Rules in Psychology," Psychological Review, 1971, 78, 151-169; Veit, C. T., "Ratio and Subtractive Processes in Psychophysical Judgment," Journal of Experimental Psychology (General), 1978, 107, 1, 81-107.

(1) Design judgment experiments that allow
- *tests* of hypothesized effects shown in the STF structure
- *tests* among algebraic functions hypothesized a priori to measure effects found in the data.

(2) Collect judgement data from SMEs

(3) Analyze data to determine
- how training variables affect judged mission performance
- the appropriate algebraic functions to measure those effects and causally relate aircrew and unit training to combat mission effectiveness.

The algebraic functions are theories of how situational information affects respondents' (SMEs in this case) judgments. (For example, SMEs might be asked to judge the likelihood that their battalion, undergoing a particular training program, would successfully execute its close support mission in Central Europe.) When the STF approach employs algebraic modeling methods, conclusions about how factors affect outcomes are based on expert judgment and tested premises. Both of these features lend credibility to resulting conclusion. It is the testability feature, however, that provides the scientific base for the conclusions. Effects of hypothesized factors and predictions of algebraic functions are *tested* and rejected if not supported by the data.

THE STF TRAINING/EFFECTIVENESS STRUCTURE

In the STF method, factors and factor levels are determined through interaction with the SMEs. The 21 SMEs who participated in the research reported here were commanders, operations officers, and instructor pilots from 3 corps squadrons and 2 division battalions.

Figs. 1-5 describe the STF training/effectiveness structure.[4] Figure 1 describes the complete 4-tiered STF training/effectiveness structure. The first 3 tiers from the bottom up depict the factors hypothesized to affect suboutcomes--crew flight proficiency, crew mission proficiency, and company mission effectiveness; the top tier depicts the 4 factors hypothesized to affect the final outcome--battalion mission effectiveness.

Factor levels associated with the factors in each tier are shown in Figs. 2-5. The bottom tier, Fig. 2, hypothesizes that 5 factors are important in determining crew flight proficiency[5]--how many hours per month each aircrew member flies the Apache, how many NVS and CMS flights they have per month, what percent of the time they train as a crew, and their crew experience.[6]

Fig. 3 depicts 4 factors hypothesized to affect crew mission proficiency: flight proficiency on the ATM tasks, how often the crew trains on a particular company mission, how often they train in the combat mission simulator (CMS) on that mission, and the type of mission. The mission type could be close support, day or night, in the forward area against armor, deep operations (from 20 km. to 100 km. behind enemy lines) against armor, or rear operations against soft targets.

Fig. 4 hypothesizes that the amount of training with the company on a company mission, the type of scout that accompanies the Apache team on the mission,[7] and the median crew's mission proficiency (i.e., how well

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[4]Acronyms used in Figs. 1-9 are as follow:

ATM: Aircrew Training Manual
NVS: Night Vision System (Apache)
CMS: Combat Mission Simulator

[5]Crew flight proficiency was defined as the percent of aircrew training manual (ATM) tasks the crew could perform almost perfectly ("with the grade of A") on a given check ride.

[6]A senior crew member was defined as a pilot with 500 hours or more flying time in the Apache; a junior crew member was a pilot with less than this number of total flying hours in the Apache.

[7] The LHX is armed, has state of the art optics, an automatic target hand-off system (ATHS), an automatic target recognition (ATR) system, and can laser-designate for the Apache's Hellfire missile. The OH-58D has ATHS and laser designation capabilities; the OH-58C has none of these capabilities.

the median crew performs its role in the mission)[8] all affect a company's performance on a particular mission.

At the battalion level (Fig. 5), the median company's mission effectiveness on a particular mission,[9] frequency of battalion mission training on that mission, and a technological factor, threat system location accuracy,[10] are all hypothesized to affect a battalion's effectiveness in performing the mission.

A judgment experiment was designed for each tier in the STF structure using the factor levels. These experimental designs generated situations presented to participating SMEs for their judgments.[11]

Fig. 1 notes an STF (algebraic function) at each link in the structure. When the 4 appropriate algebraic functions are determined from the judgment data, they serve to functionally interlink all tiers of the structure; the final structure and its associated composite function is an effectiveness model for evaluating training programs. An existing or proposed training program can then be described in terms of factor levels in the structure and the composite function computed to provide a prediction of battalion mission effectiveness for that program (as well as a predicted outcome at each tier).[12] For all factors with physical values as factor levels (e.g., number of NVS flights per month,

[8]There are 5 AH-64s in a heavy attack team. A median crew proficiency of 80% states that half of the crews perform at a higher mission proficiency level than 80% and half at a lower level.

[9] There are 3 companies in an attack helicopter battalion.

[10] Threat system location accuracy refers to the accuracy with which the location of the threat systems (including the targets) are known to the battalion and passed to the companies.

[11]The nature of the experimental designs used for the 4 different judgment experiments was driven by the nature of the factors and the algebraic functions entertained as STFs. Factorial combinations of factor levels was the basic design feature. However, this design feature was extended so as to be able to test among a wider variety of algebraic functions. More details on experimental designs is presented in Veit, C. T., M. Callero, and B. J. Rose, "Introduction to the Subjective Transfer Function Approach to Analyzing Systems, The Rand Corporation, R-3021-AF, 1983.

[12]The STF is called a *transfer function*, because when the composite function is used in analyses, the output of a function lower in the hierarchy is transferred as an input factor level to the function at the next highest level in the hierarchy.

frequency of training, threat location accuracy), interpolated and extrapolated values describing a proposed training program or capability level can be used in the effectiveness analysis.[13]

RESULTS OF DATA ANALYSES FOR THE CLOSE SUPPORT DAY MISSION

Data collected to date for the close support day mission are reported in this section. Data collection and model analyses are ongoing.

Figs. 6-9 are graphs of the more salient features of the close support data. In Fig. 6, judged percent of ATM tasks performed "perfectly" (at a top level) is plotted on the y-axis. The training program is described in terms of the number of CMS flights per month (plotted on the x-axis), number of NVS flights per month (plotted as separate curves), and the total number of Apache flying hours per month (separate panels). These data are for a crew made up of 1 junior and 1 senior member who train together 80% of the time.

As can be seen, all of the curves are higher in the right-hand panel of Fig. 6, indicating that increasing total flying hours from 10 to 20 per month increases proficiency for any comparable CMS and NVS combination. Horizontal lines drawn through the curves provide information about tradeoffs among the training factors in affecting ATM task proficiency. An interesting tradeoff can be seen from the data points designated by squares. If pilots get 1 NVS flight every other month (bottom curve in both panels), the same performance can be achieved by increasing the number of CMS flights to 4 per month as increasing total flying hours to 20 per month (and keeping number of CMS flights at 1). The triangulated data point indicates that this same level of proficiency can be achieved by keeping total flying hours at 10 per month, decreasing CMS flights from 4 to 2 per month and increasing number of NVS flights to once a month. The reader can pick out many other interesting tradeoffs in these data.[14]

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[13] Interpolated and extrapolated values can be appropriately used in analyses because the STFs are tested *theories* of experts' perceptions; it's the theoretical base that permits such extensions. The theories have undergone rigorous tests; numerous vying theories have been rejected because the data did not support their unique predictions.

[14] As mentioned earlier, model analyses are incomplete. However,

In Fig. 7, crew proficiency level is plotted on the x-axis with a separate curve for the number of CMS flights per month and a separate panel for the number of times a month the crew trains with the company on the close support mission. The squared data points indicate that, for a crew at the 50% ATM task proficiency level, it is possible to achieve the same crew mission proficiency level in a program that trains with the company once a month as 3 times a month, if CMS training is increased from once to twice a month. This implies that CMS training is a very valuable tool for mission training. Two advantages to CMS training over training in the field is that pilots can really shoot at and laser designate targets.

In Fig. 8, frequency of company mission training is plotted on the x-axis; a separate curve is for each scout helicopter type, and a separate panel is for the different levels of median crew performance. Clearly, having the most advanced scout helicopter (the light attack helicopter, LHX) and training on the mission frequently (3 times a month) produces the greatest mission effectiveness, as would be expected. The squared data points in the right-hand panel indicate that a company with a median crew mission proficiency level of 80% would be expected to perform its company mission equally well in the following 2 training programs: (a) a program that trained the crews on the company close support mission only once every other month, but the Apache team was accompanied by OH-58D scouts, or (b) a program that trained the crews on the mission 3 times a month but the Apache team had no accompanying scouts.[15]

The triangulated data points in the left-hand panel of Fig. 8 indicate that crews performing at the 50% level do just as well with an OH-58D as an LHX *if* they increase their mission training from once every

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when the STF has been determined for these data, tradeoffs can appropriately be made among interpolated and extrapolated values. These data most likely closely approximate predicted values from the theoretical model, since deviations of predicted from obtained values are typically small.

[15]When an Apache team flies autonomously, the mission takes on the additional task of locating their targets and air defense threats.

other month to once a month. They can do about the same with an OH-58C if they increase their mission training to 3 times a month (diamond in left-hand panel).

Figure 9 depicts the direct tradeoffs that affect battalion mission effectiveness. Recall from Fig. 1 that the factor, Median Company Performance (separate panels), is affected by all the factors in the 3 tiers of the structure below this top Battalion Mission Effectiveness tier. Frequency of battalion training is plotted on the x-axis in Fig. 9, with a separate curve for each level of threat location accuracy.

The squared data points in the two panels of Fig. 9 illustrate a training/technology tradeoff. A battalion with a median company performance level of 50% (left-hand panel) requires a target location accuracy capability of 500 meters to perform as well as a battalion with a median company performance of 80% that uses a poorer target location accuracy device (1000 meters). Comparison of the triangulated data points in the 2 panels of Fig. 9 illustrates another training/technology tradeoff. If training is fairly poor (i.e. mission training is only once every other month and previous training resulted in a median company effectiveness of 50%), a better target location accuracy (within 1000 meters) is needed to achieve comparable battalion mission effectiveness with a better performing battalion (mission training is once a month and previous training resulted in a median company effectiveness of 80%) using a poorer target location accuracy capability (3000 meters).

CONCLUDING REMARKS

Numerous tradeoffs like those described above can be seen in these data. Knowledge of the tradeoffs provides information about the effectiveness of alternative training programs. At the present time, the Army is unlikely to increase the number of flying hours. These data indicate it is possible to improve proficiency of aircrews and operational effectiveness of units within the current flying-hour program. Also, it is evident from the scout/training tradeoffs seen in Fig. 8 and the threat location accuracy/training tradeoffs seen in Fig.

9 that increases in training can provide comparable or greater effectiveness increases than technological improvements. This is not to say that the Army shouldn't purchase advanced technology. Mission effectiveness improvements are greatest with improvements in both areas.

When completed, the effectiveness model shown in Fig. 1 can be used as a guide for changing training programs. Major considerations to such changes would be cost, manpower, and local constraints such as training areas and restrictions on night flying.

An interesting extension to this project would be a cost/benefit analysis where costs could be manipulated and benefits could be judged by SMEs in a framework like this that supports causal conclusions.

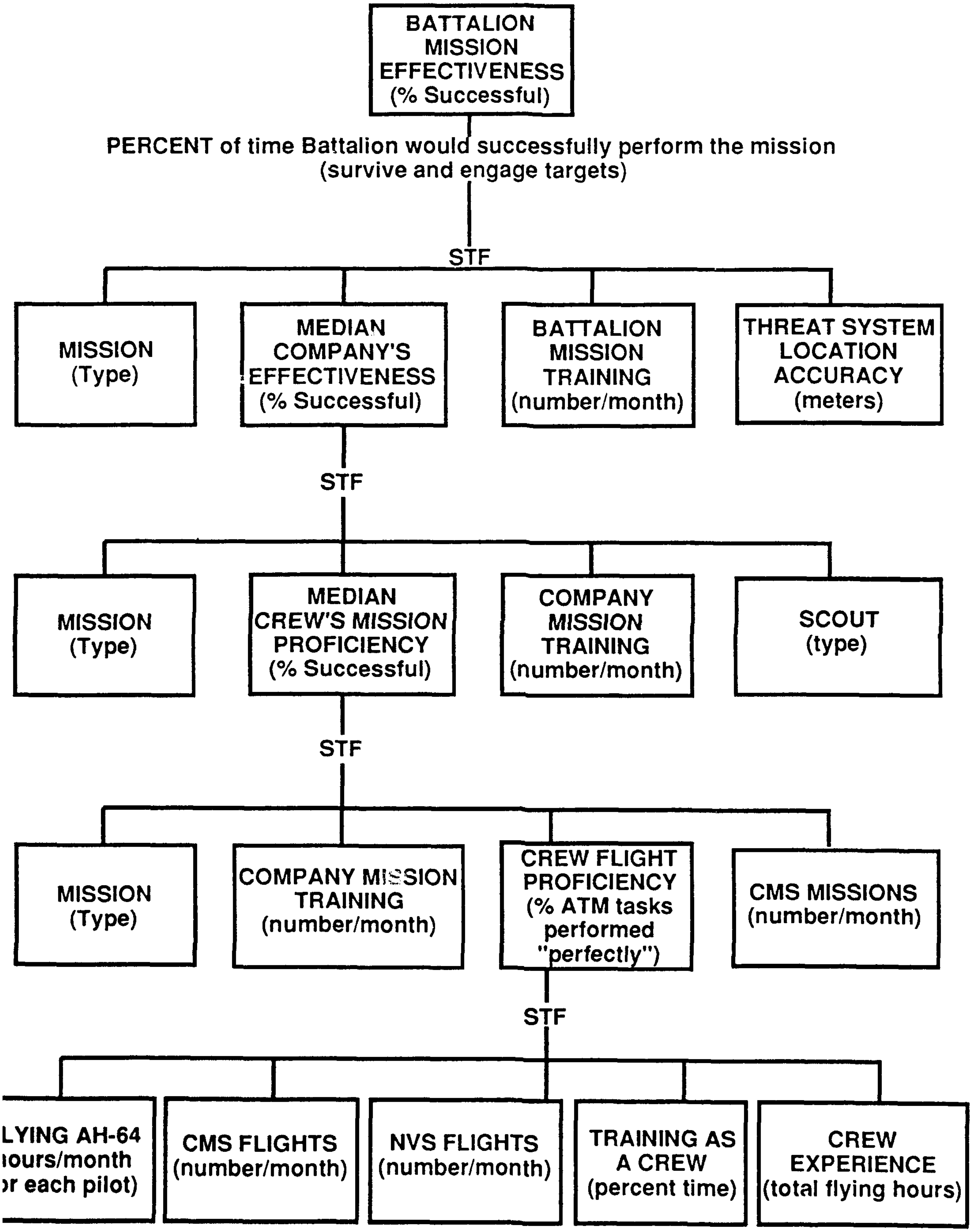

Fig. 1—STF Structure of Causal Hypotheses

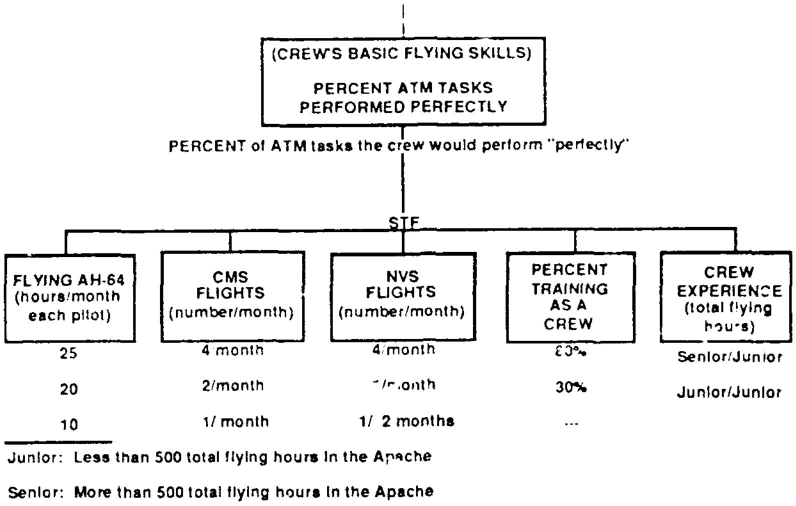

Fig. 2—STF Crew Flight Proficiency Structure

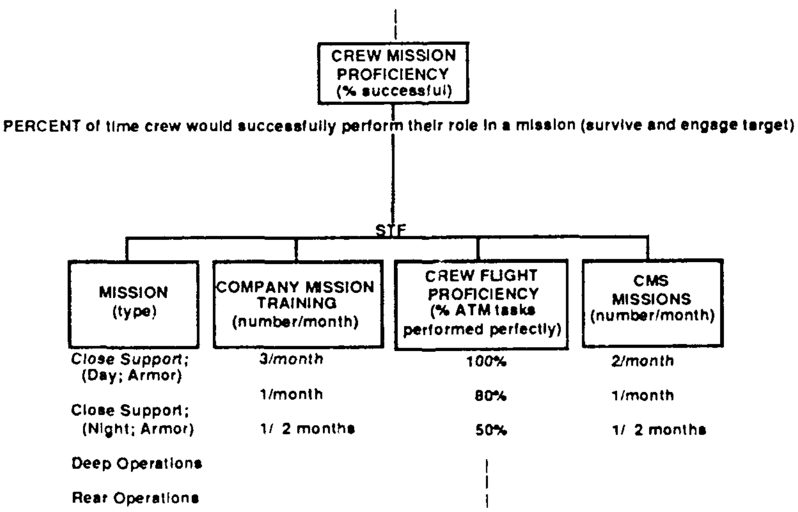

Fig. 3—STF Crew Mission Proficiency Structure

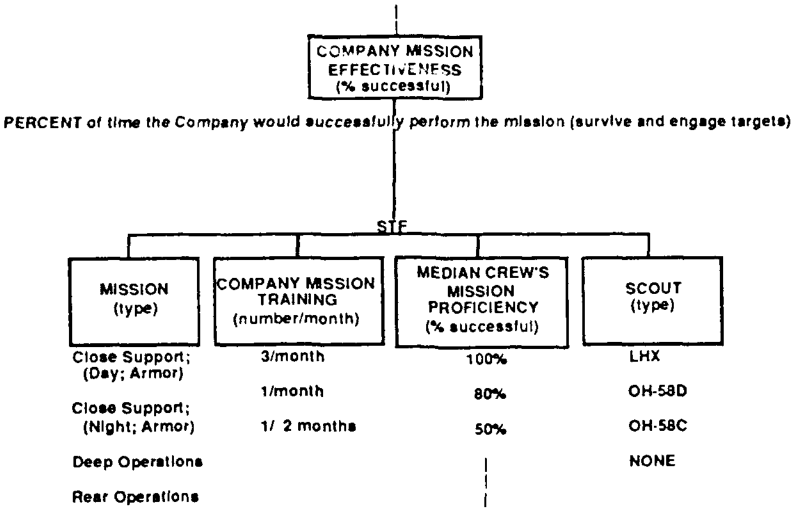

Fig. 4—STF Company Mission Effectiveness Structure

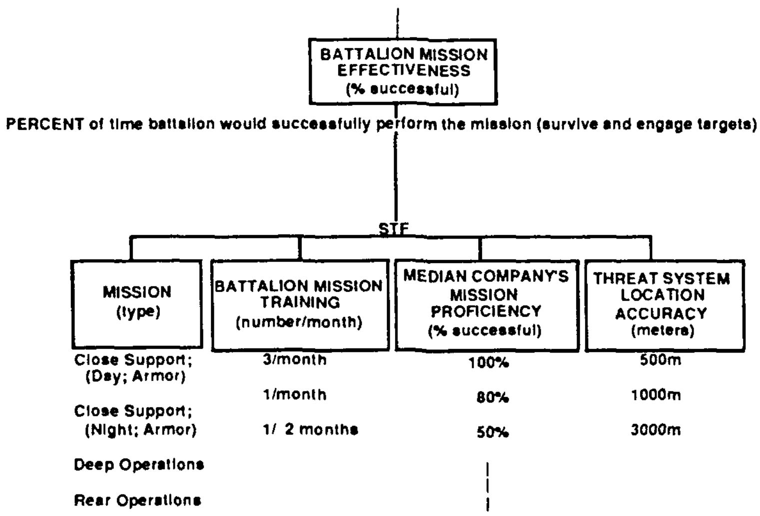

Fig. 5—STF Battalion Mission Effectiveness Structure

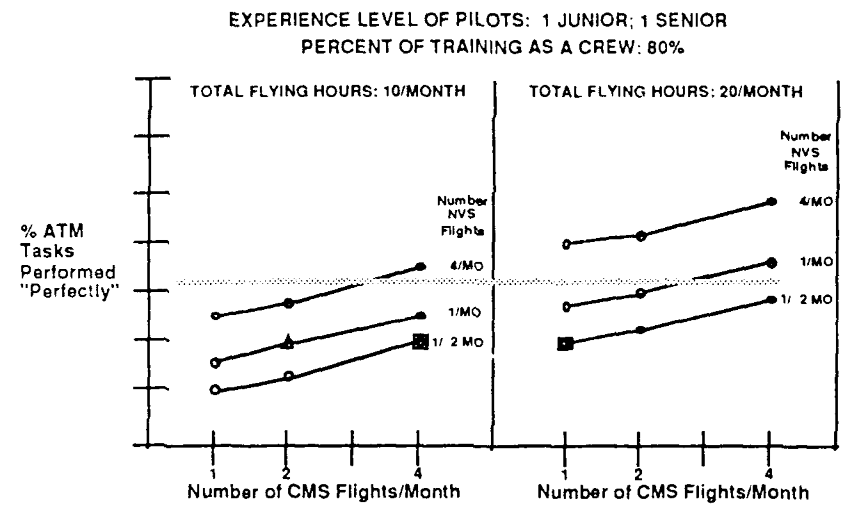

Fig. 6—Crew Flight Proficiency

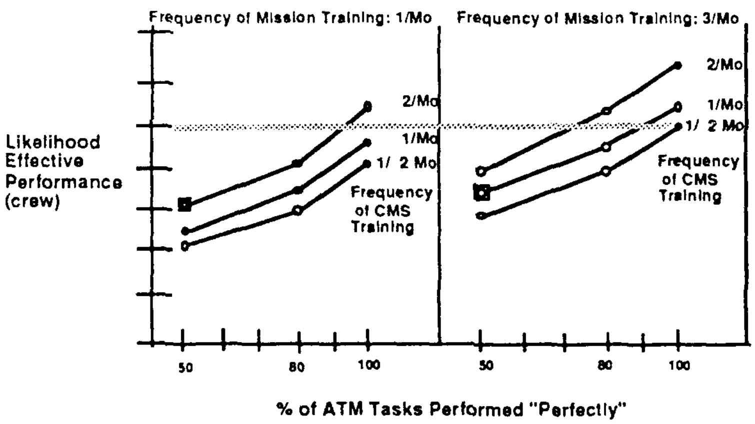

Fig. 7—Crew Mission Proficiency
(Close Support, Day)

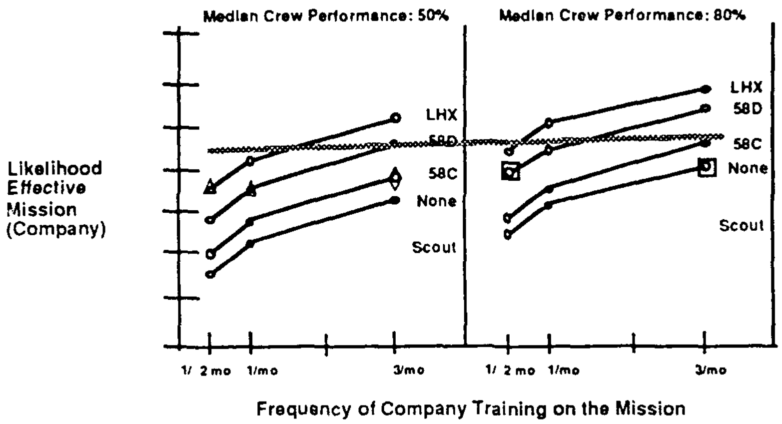

Fig. 8—Company Mission Effectiveness
(Close Support, Day)

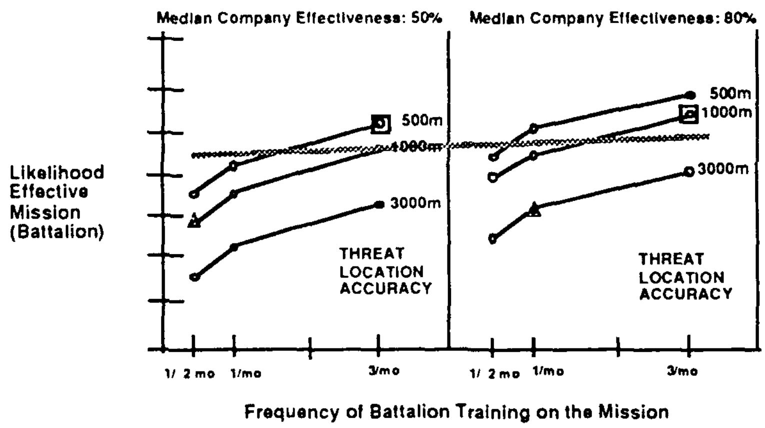

Fig. 9—Battalion Mission Effectiveness
(Close Support, Day)